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Queensland.

DEPARTMENT OF MINES.

Queensland Geological Survey.

(B. DUNSTAN, CHIEF GOVERNMENT GEOLOGIST.)

PUBLICATION No. 264.

Silver Spur Mine.

Recent Developments and Future Prospecting.

WITH TWO MAPS, SEVEN PLANS, AND FOUR PHOTOGRAPHS.

By LIONEL C. BALL, B.E. (Syd.), Government Geologist.

BRISBANE:

BY AUTHORITY: ANTHONY JAMES CUMMING, GOVERNMENT PRINTER.

1918.

NATIONAL MUSEUM VICTORIA

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Silver Spur Mine.

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and
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Introduction.

The Silver Spur Mining Company, No Liability, having in 1916 petitioned the Mines Department for the services of a geologist, the writer was instructed to make an inspection of the mine and to advise the management as to future prospecting. My own observations had already convinced me that plans depicting all faults and crush zones were essential to a proper understanding of the nature and origin of the Silver Spur ore-bodies and the formulation of any sound scheme of exploration. Consequently, several weeks in August, September, and October of 1916 were devoted to an investigation of the workings as far as they were accessible. Mr. Hall placed every facility in my way, made over to me all plans in his possession, and placed at my disposal in surveying and examining the workings his underground manager, Mr. H. Stey, whose assistance and local knowledge were invaluable.

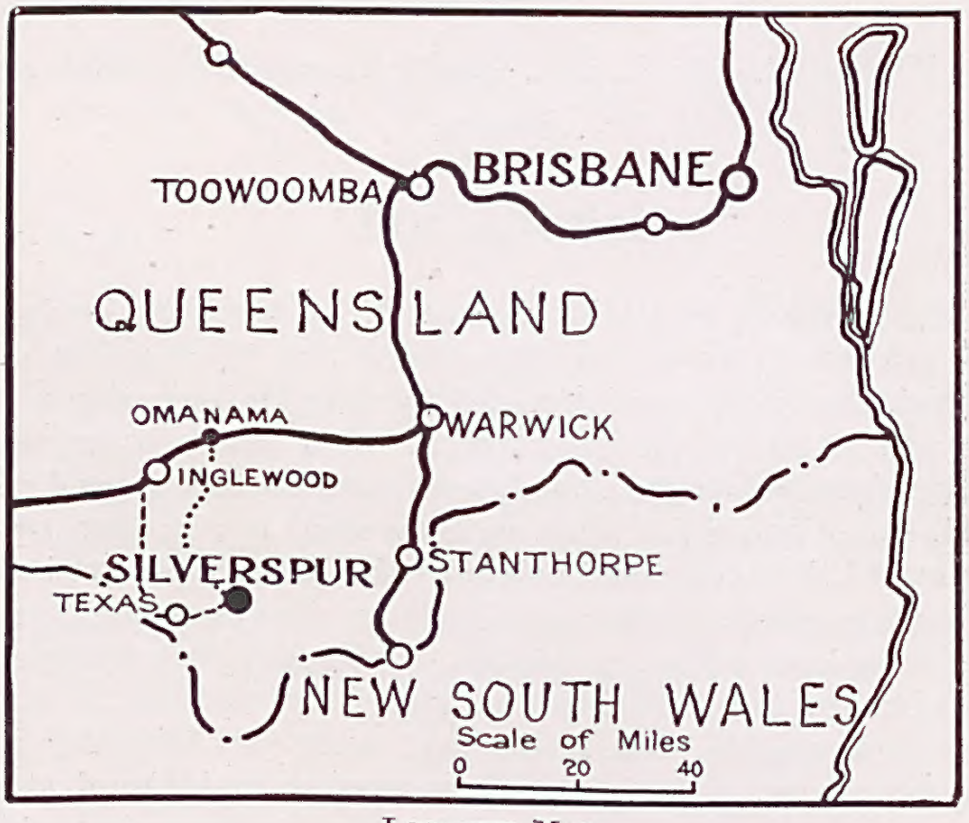
Opportunity was taken to map in also the physical features of the small mining reserve at the mine; but a complete geological survey was found to be impracticable without embracing a much larger scope of country than the time at my command and the ostensible reason for my presence at the mine warranted.

For the purposes of the examination all accessible workings had to be resurveyed (using prismatic compass and chain). In the preparation of the plans reliance has, wherever possible, been placed on the field data, but on account of the close timbering in many parts of the mine and the large amount of stoped-out ground, the observations have had to be reinforced by assumptions as to the formations; and for the worked-out ore-bodies recourse

has been had to the old mine plans, though in most cases they show a single body or stope instead of the actual group of lenses with separating sheets of formation.† My field plans have already been made available to the management, and it is understood that they are serving to control the exploratory work that is now in progress.

Location.

The Silver Spur Mine is in close juxtaposition to the township of the same name in the county of Clive, on the Darling



Locality Map.

Downs. It lies 6½ miles east of the border town of Texas and a little less than 4 miles from the nearest bend of the Severn or Dumaresq River.

For the more thorough utilisation of the pastoral, agricultural, and mineral resources of the country about Texas, a branch line from the South-Western Railway is proposed and has been authorised by Parliament, with Silver Spur as a terminus at 43¾ miles from Inglewood. The distance by road from Silver Spur to Oman-ama, the most convenient station on the existing railway, is 42 miles, and the teamsters make the return journey in one week.

† Mr. Stokes's own plans are always useful because of their wealth of detail.

The mine rests on the southern slope of a long spur that comes down from Mount Gunyan to gradually lose itself in the wide flood plain of the Severn River, the valley of which in this part is one of mature aspect, with its low relief and prevailing rounded contours. By aneroid Silver Spur is 230 ft. above Inglewood railway station, and consequently it is about 1,150 ft. above sea-level. The post office is approximately 350 ft. above the Severn River (at Gunyan homestead).

History.

The Silver Spur lode outcrops are known to have been discovered in the year 1890, but the first official recognition was that of the Mineral Lands Commissioner in the following year. Several leases, including M.L. 54, were applied for towards the end of 1892, and the year is credited with a small production,

Silver Spur.
As seen from the north-west in 1916.

but no matte was shipped till 1893, when Mr. Edgar Hall, the present manager and until recently the chief shareholder, took over the old Texas reverberatory furnace and started mining. The Silver Spur Mining Company, No Liability, was formed privately in 1894.

Developments continued favourable on M.L. 54, and the company during the first four years of its life distributed dividends exceeding £20,000; but comparatively little work was done to prove an extension of the ore-bearing formation beyond that lease, the most important effort being the sinking of Lawson's shaft in 1897 by the Silver Spur Extended Company, then holding leases to the north-west and south-east of the original company. This attempt followed on the discovery of No. 4 ore-body in the drive along Stokes's fault, but though the fault was located by the Extended Company and followed for 100 ft., no ore was found, and operations were rather prematurely suspended on the completion of the first and only contract let.

A new 20-ton furnace was completed in 1898, but in the same year it was recognised that the gossans were practically exhausted, and this involved the management in other innovations. For the better prospecting of the ground a hand diamond drilling plant was purchased in 1899, and an air compressor and rock drills were installed. Then for the more economical treatment of the sulphides an Austin pyritic smelter was erected. For the recovery of the lead from the slags a blast furnace was built, but its operation was only partially successful, owing to troubles caused by the presence of zinc, and its use was discontinued towards the end of 1901.

The 300-ft. level was opened in 1902, the big ore-body was discovered, and the permanency of the mine was regarded as assured. In 1904 a trial lot (100 tons) of zinc ore, valued at £5 3s. 4d. per ton, was sent to England and returned a small profit. In 1905 considerable additions were made to the plant and the reverberatory furnace was rebuilt. Sinking of the main shaft below the 300-ft. level was resumed in 1906. A Sydney company, known as the Silver Spur Proprietary, held the ground adjoining and to the south of M.L. 54, including what is now the Silver Spur tailings area, and in 1907 sank a vertical shaft within a few feet of the boundary to a depth of 150 ft., but without receiving any encouragement to proceed.

The year 1908, with a throughput of more than 9,000 tons of ore, saw the zenith of the senior company's activities, for, notwithstanding the discovery of the ore-bodies at the 400-ft. level, the production fell away till in 1913, the last year officially credited with any output, it was less than 3,000 tons. The decrease of 1909 was attributed to disorganisation caused by the dismantling of the two reverberatory furnaces and their replacement by one of double capacity. A pleasing feature of the year was the improvement in the gold values in the ore obtained from below the 400-ft. level—from less than 1 dwt. to more than 2 dwt. per ton treated—but this did not prove permanent. Already in 1910 the management was investigating the possibilities of various new zinc recovery processes, and probably had capital been forthcoming something might have been done with the Murex.

In 1911 the decline in the copper content of the ore began to be felt; some development was carried out in the zinc ore-bodies; and at the same time the feasibility of re-treating the slags, estimated to contain £400,000 worth of metal, first received serious consideration. The trial railway survey, to connect Silver Spur with Texas and Inglewood, was completed during 1912; and the management was encouraged thereby to sink the

main shaft to 520 ft. depth. Developments on the 500-ft. level, however, were much below expectations as far as silver values went; and most of the relatively small amount of ore smelted during the year came from stopes above the 400-ft. level; but a parcel of 63 tons of zinc ore was sent for trial to Europe.

The decrease in metal contents, and especially the want of copper to serve as a collector of the gold and silver, forced the management to abandon smelting operations in 1913; but arrangements were made to instal mechanical concentrators for the treatment of the zinciferous formations of the lower levels, and one table was purchased, but the projected milling scheme has remained in abeyance. During 1914, the Mines Department subsidised the company's effort to prospect by driving on the 500-ft. level, but the work was suspended before anything of value had been revealed. In the same year a Bill authorising the construction of the railway to connect with the main South-Western system of the State was passed by Parliament, but there the matter rests, and the management insists that, until the railway is in operation there is little prospect of the requisite plant—for the treatment of either the metalliferous slags or the low-grade formations of this mine—being erected.

The year 1915 was marked by a little costeaning on the surface, resulting in the revelation of favourable indications to the south-east of No. 3 ore-body. During the year 1916 a new ore-bearing formation was discovered by Mr. Hall beyond No. 4 on the 150-ft. level, and arrangements were made to open it up.* The company, however, was now suffering from shortage of funds, and late in the year permission was sought from the Federal Treasurer to reconstruct by forming a new company to be known as Silver Spur Limited, with an issue of debentures for the acquisition of fresh capital on account of immediate requirements, and with provision for a further issue of shares at the end of the war or when the railway is opened, on account of a zinc-treatment plant.

Bibliography.

1892, *et seq.* Annual Reports of the Department of Mines, Brisbane. Statements of progress by the Mineral Land Commissioners and Wardens for the Stanthorpe district.

* Under date 9th May, 1918, Mr. Hall writes: "We have opened a shoot of ore 30 ft. long at the 150-ft. level, No. 1 lode, on the hanging-wall side from the crosscut (in the right-hand lower corner of square 1-2 NW of your plan) and it appears strong under foot and to pitch southwards. We are sinking a winze on it."

Under date 19th May, 1918, he states: "We are sinking a winze at the 200 to continue that sunk by Stey on the new lode."

1898. G.S.Q. Publication No. 120. "On the Geology of the country round Stanthorpe and Warwick, South Queensland, with especial reference to the Tin and Gold Fields and the Silver Deposits." By Sidney B. J. Skertchly, late Assistant Government Geologist.

1899. Proceedings of the North of England Institute of Mining and Mechanical Engineers. "The Ore Deposits of the Silver Spur Mine and Neighbourhood, Texas, Queensland." By H. G. Stokes.

1902. Annual Report of the Department of Mines, Brisbane. Special report on the Silver Spur Mine. By Edgar Hall.

1904. G.S.Q. Publication No. 191. "Notes on Tin, Copper, and Silver Mining in the Stanthorpe District." By Lionel C. Ball.

1910. Unpublished Memo. for the Under Secretary for Mines, Brisbane. By Lionel C. Ball.

1914. G.S.Q. Publication No. 243. "Geology and Mineral Resources of Stanthorpe, Ballandean, and Wallangarra." By E. C. Saint-Smith.

Production.

In the compilation of the subjoined Table A reliance has been placed primarily upon the records in the annual reports of the Department of Mines, but these have been supplemented by figures obtained from Mr. Edgar Hall, and for the purpose of arriving at the approximate total output of the mine interpolations for the earlier years have been needed.

The products marketed have comprised complex silver ores and high-grade zinc ores, lead bullion, and copper-lead mattes, the last mentioned in by far the largest quantity.

Prospecting.

The work of prospecting by blind-stabbing at the Silver Spur Mine has been facilitated by the company possessing a hand-power diamond drill, but the results have been most inadequately recorded. Mr. Hall handed over to me the driller's timebook, which usually records the date of operating and the level, but seldom the exact position of the plant or the direction drilled. By close study of the book and of the underground workings most of the bores mentioned have been located, and, notwithstanding the paucity of data recorded for all except the latest bore holes, which were drilled under Mr. Hall's personal supervision, the drill holes have been plotted with much advantage

Table A.—Production Table.

Year.	Ore.		Matte.	Silver.		Gold.		Copper.		Lead.		Zinc.	
	Raised.	Treated.	Produced.	Total.	Per Ton	Total.	Per Ton.	Total.	%	Total.	%	Total.	%
	Tons.	Tons.	Tons.	Oz.	Oz.	Oz.	Dwt.	Tons.		Tons.		Tons.	
1892 ..	..	10*	..	280S_1	..	..	..	20S_1	..	..	..	..	..
1893[1] ..		1,100	..	17,128S_1	..	..	..	100S_1	..	..	..	..	..
1894 ..	2,904	2,904	..	85,067S_2	38	..	..	..	..	..	..	..	..
1895 ..	3,134	3,000	..	106,940	34	..	..	..	..	..	..	..	..
1896 ..	..	3,000*	..	122,421S_2	..	..	..	60S	..	..	..	..	..
1897 ..	..	3,000*	..	113,822S_3	..	..	..	72S	..	..	..	..	..
1898[2] ..		3,000*	..	60,000S_4	..	..	..	nil	..	..	..	..	..
1899	5,046	..	..	75,698S_5	26H	..	2·0H	64S_5	..	..	..	..	..
	4,909H	3,978	184·5	92,032	23	120	0·6	48	1·2	..	..	..	..
	..	..	..	110,316H	..	562H	..	55H	..	69H	..	..	..
1900[3] ..	..	3,012	126·35	65,914	22	44·2	0·3	30·5	1·0	63	2·1	..	..
1901[3] ..	..	3,000*	..	75,055S_2	..	..	..	35S	..	200S	..	..	..
1902	4,344	3,181	149	77,399H	24	111	0·7	44·2H	1·4	50H	1·5	..	..
	..	..	..	..	28·5	..	..	..	1·0	..	..	..	..
1903 ..	5,064	3,803	108	96,000H	..	147H	..	31H	..	45	1·2	..	..
1904 ..	5,560	..	..	..	23	..	..	..	..	..	17	..	38
	100	4,807	..	121,260	25	171	0·7	42	0·9	49	1·0	..	..
1905 ..	4,980	7,534	238	140,882	19	241	0·6	70·6	0·5	74	1·0	..	..
1906 ..	..	6,721	..	166,869	25	202	0·6	78·5	1·2	61	0·9	..	..
1907 ..	..	7,231	..	151,972	21	224	0·6	77·9	1·1	83	1·1	..	..
1908 ..	..	9,257	..	176,682	19	393	0·8	87	0·9	106·8	1·1	..	..
1909[4] ..	..	4,908	..	110,316	22	559	2·2	55	1·1	69·2	1·4	..	..
1910[5] ..	..	7,830	..	101,528	13	718	1·8	48·6	0·6	50·8	0·6	..	..
1911 ..	..	7,320	..	124,643	17	473	1·3	69	0·9	81·5	1·1	..	..
1912 ..	1,425	2,629	..	69,237	26	171	1·3	34·7	1·3	35·5	1·4	..	..
	63	..	..	..	..	..	..	..	..	..	..	..	?
1913 ..	..	2,977	..	48,535	16	72	0·5	16·2	0·5	14·5	0·5	..	..
Total ..	..	94,000	..	2,100,000	22	..	1·0	..	0·9	..	1·1	..	..

S_1 Including Texas.
S_2 Stanthorpe M.F., chiefly Silver Spur.
S_3 Stanthorpe M.F., including Pikedale, Sundown, etc. Cu. Ag. Mines.
S_4 Stanthorpe M.F., including Pikedale, Sundown, and Severn Cu. Ag. Mines.
S_5 Stanthorpe M.F., including Sundown and Severn Cu. Ag. Mines.
H Edgar Hall.

[1] Texas furnaces rented.
[2] New furnace opened.
[3] Lead smelter operating.
[4] Furnaces dismantled.
[5] Low values due to absorption by new furnace bottom.
* Assumed.

to a complete understanding of the fault system involved. In the majority of the records the only distinctions recognised are those of the relative hardness of the country, with odd mention of quartz and ore, but Mr. Hall's descriptions are fairly detailed.

At the 80-ft. level there are four bore holes, totalling 151½ ft.; at the 150-ft. level eight, totalling 446 ft.; at the 200-ft. level nine (one missing), totalling 349 ft.; at 220 ft., one of 44 ft.; at 240 ft., two making 84 ft.; at the 300-ft. level, seven totalling 183½ ft.; at the 400 ft., fifteen totalling 628½ ft.; and at the 500-ft. level, four coming to 109½ ft. One is missing from the 200-ft. level, and there is one not located of 26½ ft. The grand total recorded is thus 2,022½ ft., representing fifty-one boreholes, of which I was able to definitely locate thirty-two.

In plotting the boreholes I have assumed that "soft" represents formation, and "hard" unaltered slate (although in some places there are hard formations), and generally the result has been consistent with mapping from the mine openings. Perhaps the most discordant result is that obtained by plotting No. 5 on the 150-ft. level, according to the driller's description, as trending due west from the main mullock pass. Large formations are thereby indicated in a quite unexpected position.

The suitability of the diamond drill for locating such irregular ore deposits as those of Silver Spur has not been demonstrated, and I personally should prefer to have future exploratory work confined to driving, crosscutting, sinking, and rising on the known formations. The wider formations might advantageously be tested by drilling at frequent intervals from these openings.

A decision as to where to initiate operations is perhaps not called for here, in view of the multiplicity of openings offering, but further development at all levels along Stokes's fault system is to be encouraged, and generally driving should be undertaken along the southward and westward trending formations. If, for example, a tracing of the plan of the 60-ft. level be superimposed upon that of the 500-ft. level, it becomes obvious how little of the possibly ore-bearing country at the latter level has been developed and what great probabilities still remain to the miner.

Reserves.

Notwithstanding the variability in size and value of the ore-bodies and the consequent irregularity of the workings; and notwithstanding that between 90,000 and 100,000 tons of ore has been smelted, and that the yield of silver has exceeded 2,000,000

oz., to say nothing of gold, lead, copper, and zinc, the company is without anything in the nature of complete assay plans, although assays have been made daily since the opening of the mine. In the absence of knowledge as to how the assays have been recorded it is to be assumed that when the ore reserves have to be ascertained, as a preliminary to resuming operations on any scale, a considerable expense will have to be shouldered.*

At the time of my inspection the reserves of high-grade ore were a negligible factor and those of low grade an unknown quantity. The management has knowledge of much zinc ore (poor in silver) left standing in the old stopes, and it is thought that if this could be mined without loss new bodies of payable grade would almost certainly be discovered. I myself am convinced that only a fraction of the ore-bodies within the formations have yet been located, because of the great expenditure involved in prospecting. An investigation concerning the possibility of exploiting and concentrating the low-grade disseminated ores of the bottom level has yet to be undertaken.

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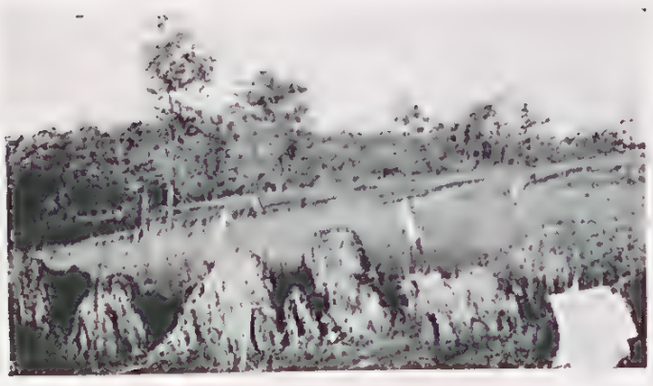
* It is fair to state that Mr. Hall is of opinion that assay plans could be compiled from his assay registers.



CRUSHED PEBBLY GRITS.
On the western side of Jack White's Hill

THIN BEDDED SLATES.
Looking south-westwards on Alpha Creek,
below Silver Spur.

JOINTED SLATES.
Near the north-western corner of the Town Reserve.

SEDIMENTARIES.

Surface Geology.

Sedimentaries.

The strata observed in the Silver Spur mining reserve comprise tuffaceous and pebbly shales, slates, and mudstones, and sandstones grits and conglomerates, sometimes highly calcareous and rich in marine fossils. The pebbles are a puzzling feature, but even more so are the boulders described by Mr. Skertchly,* who was driven to accept the ice transport theory to account for them.

The sedimentaries of Silver Spur were referred by Mr. Skertchly to the Gympie series of the Permo-Carboniferous on account of fossil corals, bryozoans, and brachiopodes found by him in sandy shales to the east and west of the township.† Mr. Stokes found crinoids on the school reserve in the township, and crinoids, producti, and spirifers may be observed in the schistose pebbly mudstone of Conglomerate Hill at the eastern end of the township and on the northern slopes of Jack White's Hill, where the shells are much distorted. The less altered fine-grained tuffaceous and pebbly shales, sandstones, and mudstones in the south-western corner of the reserve are well exposed in Copper Mine Creek, and have yielded abundant crinoids, bryozoans (*Polypora* ?), and brachiopods (*Productus brachythaerus, P. undatus,* &c.), and pelecypods (*Aviculopecten,* &c.).

Small masses of impure limestone have been exposed in the slates near the post office, but the nearest large crop of limestone lies 2 miles north-west of the mine. The presence of abundant, well preserved crinoids is proof of the organic derivation of this bed, that might otherwise have been ascribed to chemical replacement of slates.

All of the strata have been locally and variably metamorphosed. Most of the shales have been converted into prismatic slate, and the finer sandstones and grit have generally been indurated by silicification, so that in places they have the appearance of horny quartzite, but silicification has not necessarily coincided with stratification. Of such is the knoll to the north of the special lease on Hall's Creek. It is a bluish rock of

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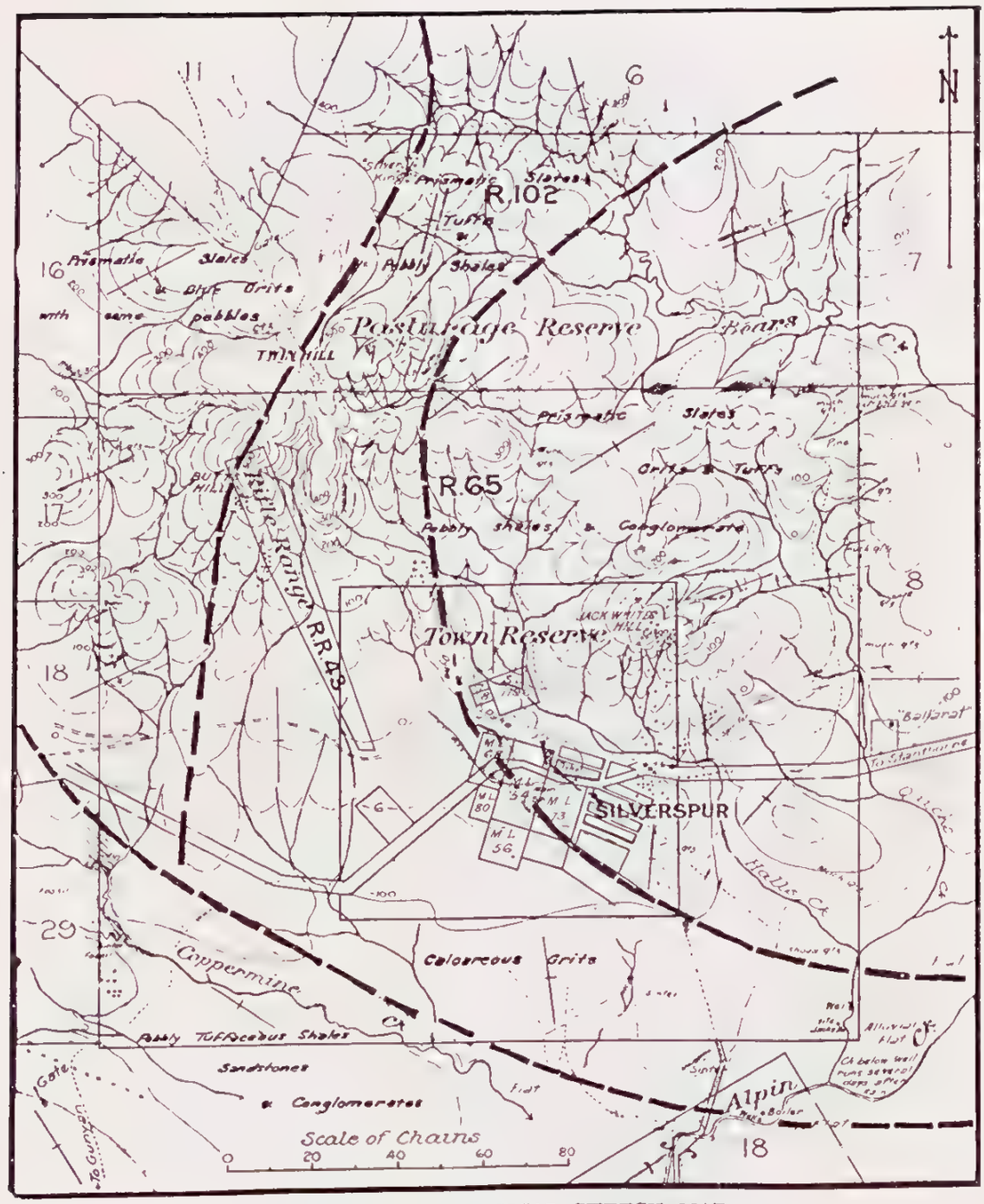
* Op. cit., pp. 8 and 9.

† Idem., p. 8.



CONTOURED GEOLOGICAL SKETCH MAP.

SILVER SPUR MINING RESERVE.

great toughness, it breaks with a sub-conchoidal fracture, and has a very fine-grained siliceous base in which minute grains of quartz are distinguishable, besides occasional small cubes of pyrite. It weathers to a depth of ¼ in., and thereby develops a reddish tint.

The variability in the intensity and trend of the schistosity, jointing and bedding in the vicinity of Silver Spur is extreme, and only by inspection can one realise the difficulty in distinguishing between the original structures due to sedimentation and those subsequently induced by the forces causing crustal movements. The stratification sometimes may be determined by bands of pebbles (as at the head of Dam Gully) or of crinoid stems (as near the dam and to the west of M.L. 68). In other places it has been assumed from the alignment of limestone or calcareous grit crops, and sometimes the crops of indurated grit have been taken as agreeing with the strike. Only very exceptionally, as to the north of M.H.L. 87 and on Copper Mine Creek, can the original bedding of the sedimentaries be unequivocally defined.

Crushed pebbly grits are well exposed in Hall's Creek above the same lease, where they have a well-marked east-west schistosity. Pebbles, up to 6 in. in diameter, are numerous, and mostly pitch at 45 degrees to the east; the harder individuals being crossed by defined joints that dip 45 degrees to the west, and along these joints slipping has taken place within the pebbles.

My inspection of the exposures near the mine has convinced me that the stratigraphy is very much more complicated than previously acknowledged, the evidence in general being contrary to the assumed uniform strike of the Permo-Carboniferous strata. After making due allowance for the extreme difficulty in distinguishing between bedding planes, joints, and crush surfaces, I have decided on a west-north-west to north-west strike for the fossiliferous tuffaceous beds in the south-western part of the reserve (though the strata on Alpin Creek below the reserve plainly strike south-west by south), and for a north-north-west to north-by-west strike for the shales and grits in the central strip; while in eastern and western areas east-north-east to east-west crush effects have superseded the forms due to sedimentation.

It is suggested that these various blocks of country are bounded by faults, in position approximating to those shown by heavy broken lines on the map of the reserve. One of them, that passing across the township, corresponds with Stokes's

fault; another agrees with the Silver King fault; and a third is indicated by the pronounced crop on the ridge above Copper Mine Creek. The faults observed on the mineral leases are shown in greater detail on the map of the township; two main slightly diverging ones striking approximately north-west, with several others interposed normally to them.

Depending then on broad generalisations rather than on particular observations, we may postulate to the north of Stokes's fault a central area of prismatic slate, with only rare pebbly and gritty beds, and usually non-fossiliferous (though crushed *Productus* was found on allotment 13 of section I. in the Silver Spur township). To the east of this area is a zone of pebbly grits and mudstones with subordinate slates and tuffs, extending southwards from Jack White's Hill. These are fossiliferous on the knoll to the east of the township and on the flanks of the hill, but in most parts all fossil remains have been crushed out of recognition. To the west of the prismatic slates we find calcareous tuffs with lenticular masses of limestone and beds of indurated grit. These contain remains of crinoids, &c.

Intrusives.

Of intrusive igneous rocks outcropping we have only the diorite. The big dyke, about 9 chains to the north-east of the main workings, has a north-west strike and is roughly parallel with Stokes's fault. Near the northern end of M.L. 54 there is a break in the crop, but the dyke has been found again to the west, within 2 chains of the line of Stokes's fault. It is possible that the cross-faulting is only apparent, and that this and other breaks in its continuity were original and constitutional with it, that is to say, that the intrusive sheet branched towards the surface into an aligned series of slabs or pipes, seldom more than a few chains in length but up to 30 ft. or 40 ft. wide.

Both in grain size and in mineral composition the rock exhibits considerable variety, being coarse and rather basic towards the south-east, but fine and rather siliceous towards the north-west. Mr. Leon Meston, as long ago as 1900, after determining the specific gravity to be 2·944, made the following partial chemical analysis of a sample from the school reserve, and on this the rock is regarded as quartz-diorite:—

SiO_2, 52·00%; FeO, 12·75%; Al_2O_3, 14·50%; CaO, 6·60%; MgO, 9·48%; K_2O and Na_2O, 1·22%; and MnO, trace.

Here and there along the dyke the grits are distinctly metamorphosed, and towards the south-east on the main street of the township they are lydianised.

Underground Geology.

Silver-lead-zinc deposits are common in many countries, especially in the vicinity of granitic and dioritic intrusions, but it is not an easy matter to pick out an exactly analogous case to that of Silver Spur. The veins of Wood River, Idaho,* are similar in many respects to those of Silver Spur. The country rocks comprise Carboniferous sediments, intruded by diorite and granite, and most of the deposits are in calcareous shale. The massive and banded ore consists of galena and blende, with a little pyrite and chalcopyrite and some quartz, but tetrahedrite is present in quantity and the gangue is a carbonate. The Clausthal deposits† are connected with crush zones in slates having foliation parallel to the planes of movement of the wall rocks that followed on faulting.

Country Rock.

The predominant country rock in the mine is a fine-grained pale-blue or greenish slaty mudstone, without any well-marked lines of stratification, but much broken up by joints. The slate on the 500-ft. level exhibits closely set cross cleavages that give a silky lustre with a slight wave effect on certain faces. In parts of the mine the rock is distinctly tuffaceous‡ in appearance, but a more pronounced characteristic is the presence, in almost every natural section and in greater or less abundance, even in the tuffs, of scattered, well-rounded pebbles, mostly less than ½ in. in diameter, of various slaty rocks. Generally the rock is indurated, but in some parts quite soft pebbly mudstones were observed. It is seldom calcareous, though gash veins of calcite, quartz-calcite, or quartz are not uncommon. In some of the upper levels gash veins of kaolinic material are exposed.

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* Wood River Mining District. By W. Lindgren. XX. Ann. Rep. U.S.G.S., pt. 3, p. 218.

† Genesis of Ore Deposits. By Franz Posepry.

‡ A specimen of the country rock from the main shaft at 460 ft. depth has been thus described by Mr. G. W. Card, Curator and Mineralogist of the Geological Museum at Sydney (in a communication to Mr. Hall): "The specimen appears to be a bedded volcanic ash . . . . . The sandy element is so pronounced that it might be described as a tuffaceous greywacke." The dark-blue rock from the footwall of the zincy lode in the wet south-western crosscut at the 500 ft. level "is a fragmentary rock, not quartzite, and it appears to be a volcanic tuff."

Sporadic nodules of pyrite were noticed enclosed in the rock at several points quite distant from the ore-bodies. Partial replacement of the rock by sulphides was noticed first at the 60-ft. level; complete replacement is strongly in evidence at various lower levels; but in the bottom level partial replacement again prevails over the area developed by mining operations. When crushed and moistened the slate appears dark-blue or almost black, so that it has come to be regarded as graphitic, but only traces of carbon have been detected by chemical analyses,* and the slickensided faces, on close examination, are found to be not at all carbonaceous in appearance, and moreover most of the coloration fades remarkably during simple desiccation of the material. Bleaching of the blue slates along joints is regarded by the management as indicative of the proximity of ore-bodies.

Fine-grained grits, mostly blue-grey in colour, were noticed in several parts of the mine, sometimes impregnated with pyrite, and often veined with thin films of quartz-calcite, but only exceptionally calcareous themselves.

Small masses of impure limestone have been exposed in the mudstones outcropping on the mineral leases, and also in driving north-west from Lawson's shaft at the 70-ft. level. Nodules of impure fibrous calcite (possibly altered limestone) are to be seen in the slates near the ore-bodies on the 200-ft. level; and in the same workings is an impure pale-blue crystalline limestone scarcely distinguishable from the adjacent slates into which it seems to merge.

Formations.

The formations consist of more or less crushed and mashed rock† (mostly pale coloured slate or mudrock) that, owing to its highly-polished slickensided surfaces and absorbed water, usually appears much darker than the adjacent country, even when free of sulphide ores. It is commonly regarded as graphitic, but some samples that when first collected appeared

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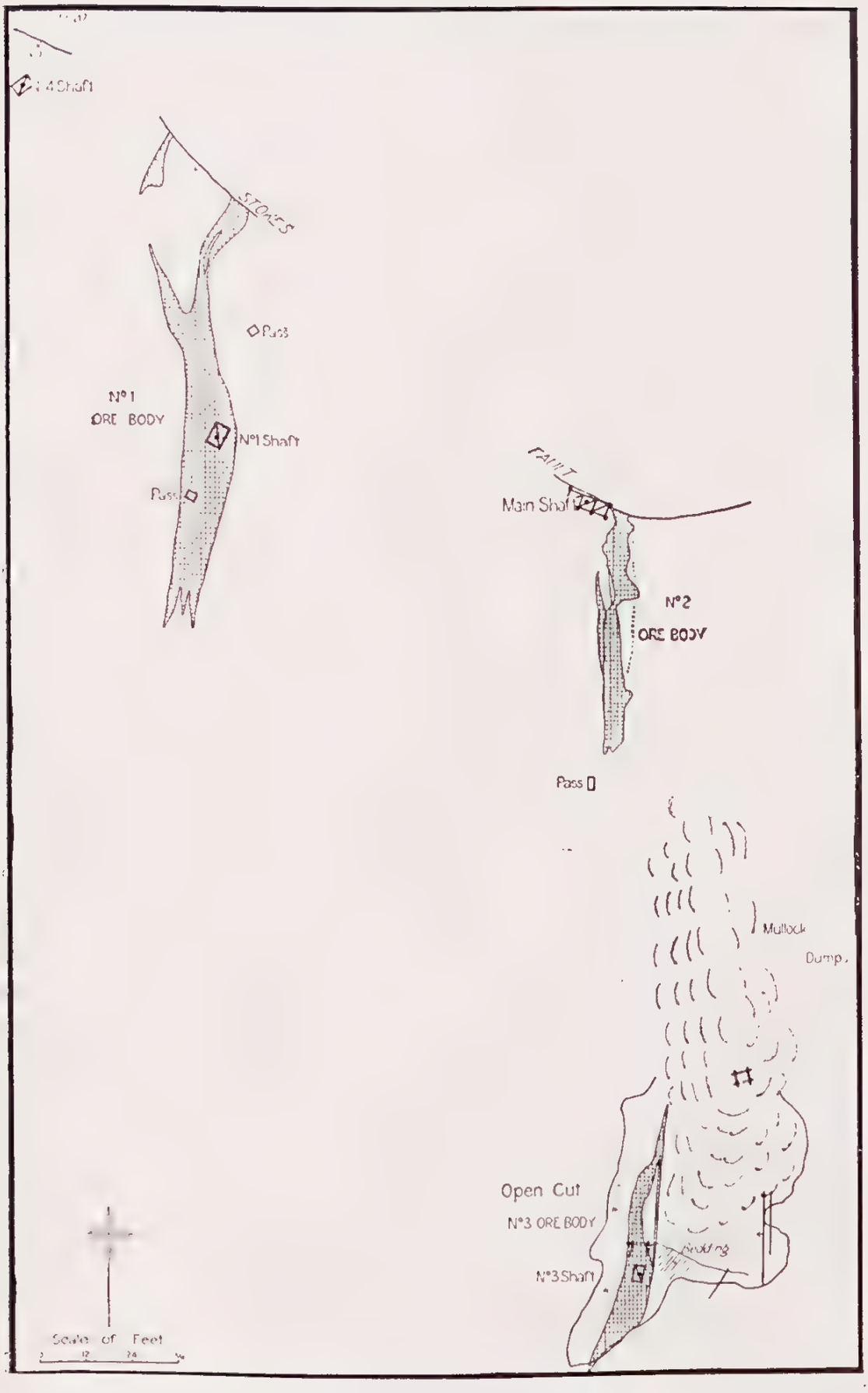
* The "black carbonaceous shale" from the wall of the orebody in the south-western stope on the 300 ft. level has been certified by Mr. F. L. Watt, F.I.C., F.C.S., to carry carbon (existing as organic matter) equal to 0·43%.

† The "shale" (presumably crush formation) from near the fault in the north-west drive on the 200 ft. level has a specific gravity of 2·678, as determined by Mr. Leon Meston, whose analysis of the rock is as follows:

SiO_2, 67·43%; Al_2O_3, 12·75%; Fe, 4·97%; CaO, 1·628%; MgO, 2·78%; and S, 0·840%. From this it would appear that the calcite content is 2·9% and that pyrite amounts to 1·6%.



PLAN OF OUTCROPS, SILVER SPUR.

jet-black, after drying exhibited at most a pale blue tint, and the dark tint of others must be ascribed to silicates and sulphides. The production of semi-translucent silicates on the crushed surfaces is a feature of the formations, and in the upper levels a white absorbent kaolinic substance is abundant along the crush surfaces. Lenticular masses and veins of quartz occur in the lower levels, where also partial silicification of the crush material has taken place.

Quartz-calcite veins, seams, and lenses are a feature of most of the formations. In some cases the calcite forms a separate deposit lying along a quartz vein, but more often the two minerals completely interpenetrate, though the calcite is probably in all cases younger than the quartz.

Calcite becomes abundant in depth. Sulphides are found in rounded and lenticular masses of all sizes (from that of a goose-egg upwards) and of variable composition (as mentioned elsewhere). They are to be seen as interlaminations and as disseminations (in distinct crystals at the 500-ft. level); but sometimes their presence is denoted only by the relatively high specific gravity of the material.

There has been an excessive development of low-grade formations at the 500-ft. level. They are there of two types. The less crushed slate is impregnated with blende, pyrite, chalcopyrite, and galena. The highly crushed formation includes lenses of sulphide, chiefly reddish blende, with a sprinkling of chalcopyrite and traces of galena, and where the sulphides fail calcite increases in quantity.

The relationship between the so-called faults and formations of Silver Spur hitherto has been shrouded in doubt and a matter for dispute;* but by the aid of the plans now submitted it can be demonstrated that there is little essential difference between the faults and the formations, and that both can be traced back to simple-joint planes. It becomes self-evident that the formations represent crushed material along joints that bound greater or less blocks of country, as first suspected by Mr. Hall many years ago, and it is now suggested that the crushing was brought about by the grinding and slipping of these blocks one upon another during the period of igneous activity.†

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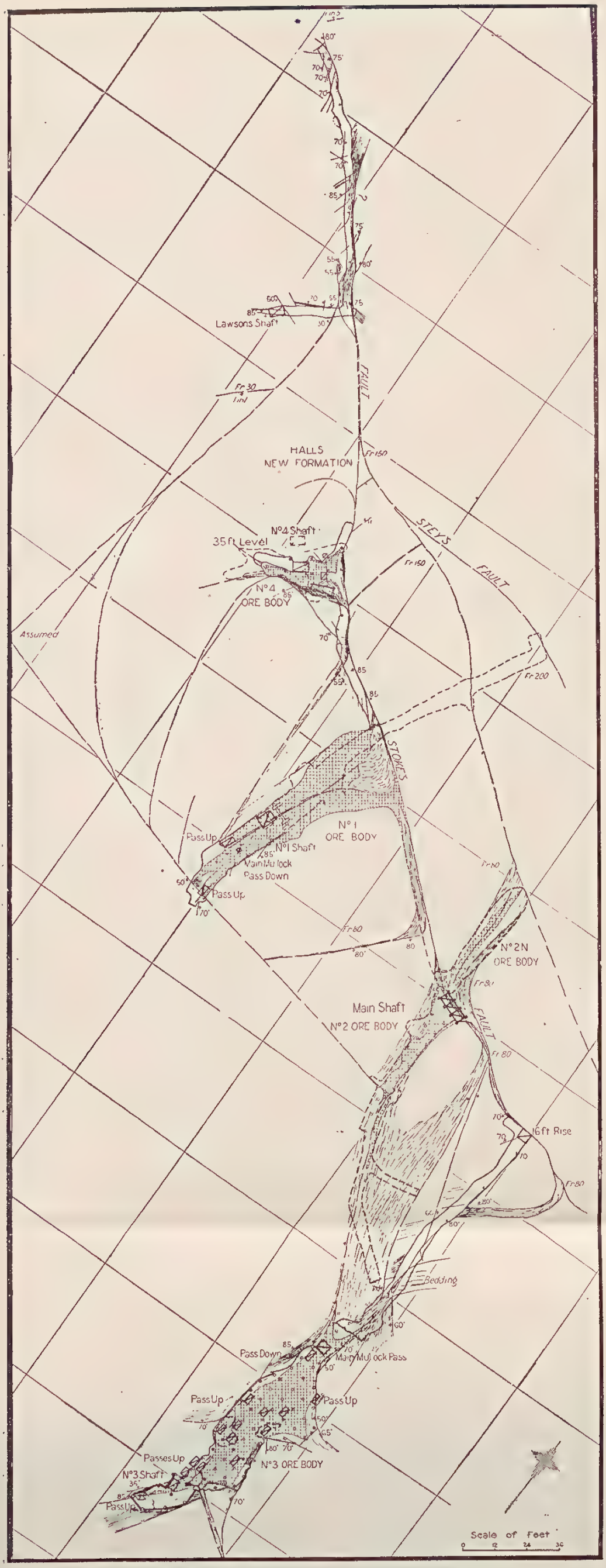
* Mr. Skertchly speaks of the ore bodies as bedded veins, while Mr. Saint-Smith is of opinion that the ore bodies are "identical in origin with those of the Western Australian Goldfields," and he describes them as occurring within a zone of crushing and shearing, with the individual lenses disposed in echelon at an angle across the main line of crushing.

† Skertchly recognised that the extreme variability in strike and dip of the strata point to axial rather than regional disturbance, the cause lying in the intrusion of a granite magma.



PLAN OF 60-FT. LEVEL, SILVER SPUR.

C

Like the formations, Stokes's group of faults, that limits the ore-bearing formations in the north-east, is in my opinion older than the ore-bodies; and consequently search beyond it for their supposedly missing portions is not to be encouraged. Near the surface there has been only subordinate crushing along Stokes's fault, though the formations normal thereto are pronounced; but on the 200-ft. level and below there is no lack of crushing in the vicinity of the fault. The significance of the slide at the end of the ore-body on the 400-ft. level is obscure because of paucity of exposures at the important points. It has been assumed that the hanging- and foot-walls have not suffered appreciable relative dislocation.

Ore Deposits.‡

The high-grade ore-bodies, all of which are confined to the crush formations, occur predominantly in lenticular form, but there are all kinds of modification between ovoid and tabular. Some are simple and strung out in series along the formations, but they frequently are found overlapping, and some of the larger bodies are compound, being built up of numerous lenses closely packed. That they are replacement deposits is fully revealed by the internal structure, which closely simulates that of the adjacent and usually crushed country rock, to which the ores often gradually give place. Banding also is common, while crustification characteristic of precipitation in open spaces is altogether wanting.

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‡ Mr. Skertchly has published a full account of the ore-bodies exposed at the time of his visit, describing them as rough lens-shaped masses wedged as it were in the bedding planes of the shales. "The main masses are due to the substitution of metalliferous mineral for the country rock, and in several places the one passes so insensibly into the other that it is hard to say where the ore ends and the rock begins. The mass is shown to be divided into floors generally dipping slightly to the south-west and evidently contraction places like the more vertical joints. In conclusion the deposits are claimed to be not true fissure lodes in the strict sense, but fissures subsequently modified, and owing their origin to deep seated influences; whence they have a chance of being permanent, but from their very nature they may be of any size and any extent, and so long as the keel or lode stuff continues there is hope of another expansion; but these kinds of fissures may and can really close." The same authority believed the ore-bodies to be cut off on the north by Stokes's fault and the fault to be newer than the ore. He leans towards regarding No. 2N ore-body as the faulted missing part of No. 1, and asserts that the question could be settled in a week, as the occasional quartzite bands ought to enable a geologist to form a fair idea of the amount of throw as well as the amount of lateral shift. It is more than unfortunate that Mr. Skertchly could not spare the time to map in any more details than are shown on the mine plans of the time, because the particular part of the mine to which he refers as so likely to give definite results is now inaccessible.

With only two insignificant exceptions to the rule, viz., the south ore-body at the 300-ft. level and the east ore-body at the 400-ft. level, the ore lenses are restricted to the zones of crushing, but it cannot be said that the size of the crush-formation is a measure of the ore deposits contained. On the contrary some of the largest formations are very poor in ore, while some of the greatest ore-bodies have but little crushed material encasing them. Moreover, in the deeper levels, partial replacement of slightly crushed country, resulting in low-grade disseminations, has operated in decided preference to complete replacement of material within the formations, and the search for high-grade lenses consequently has been disappointing.

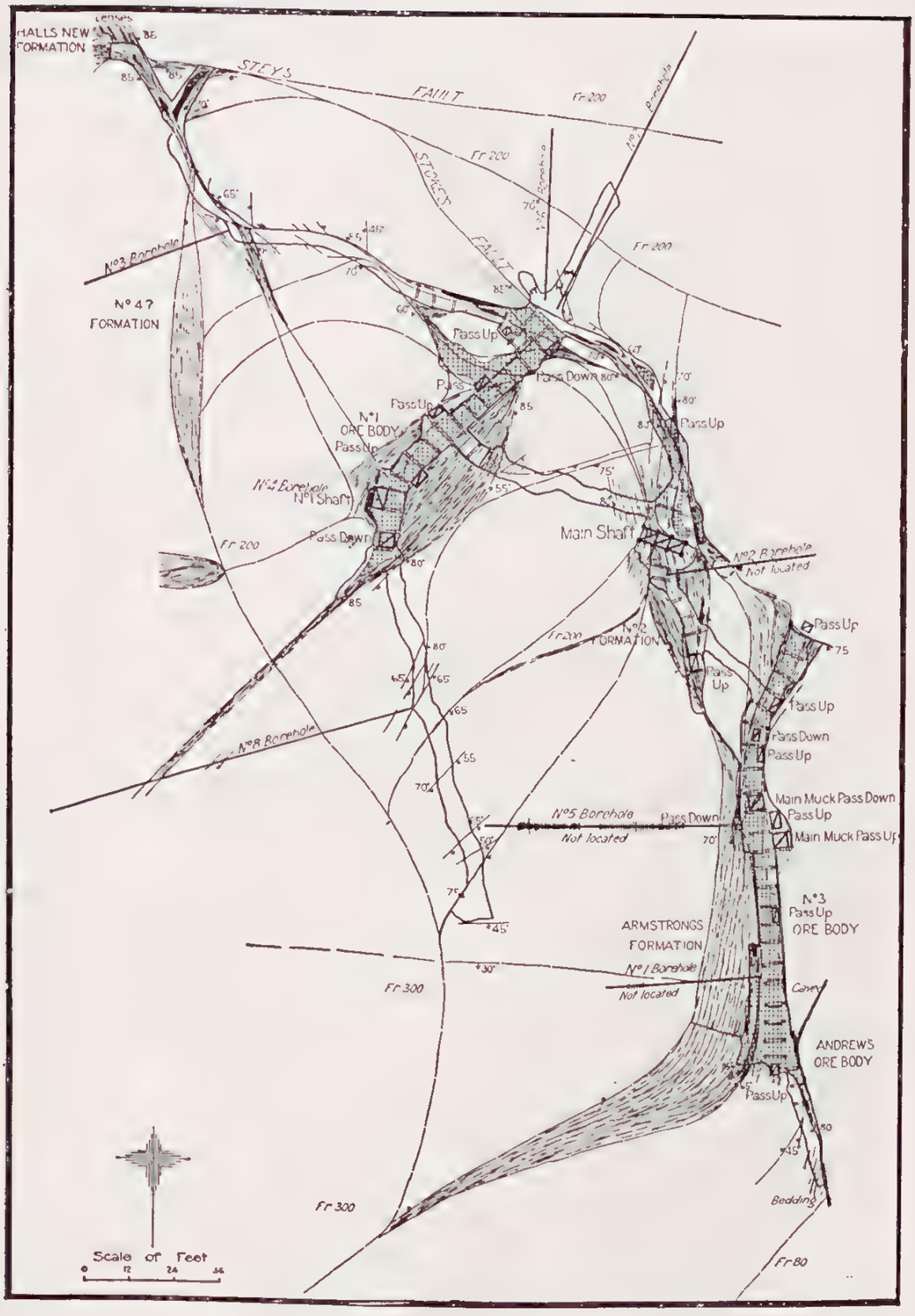
The horizontal sectional areas in square feet of the more important stoped-out ore-bodies are approximately as tabulated below:—

—	Surface.	60 ft.	80 ft.	100 ft.	150 ft.	200 ft.	300 ft.	400 ft.	500 ft.
No. 1 ..	1,200	1,260	940	..	520	..	..	..	..
No. 1A ..	..	..	..	..	..	1,260	1,260	800	..
No. 2N ..	..	120	200	..	..	..	..	..	..
No. 2S ..	370	340	210	30	..	..	..	..	..
No. 3 ..	360	960	900	..	720	360	850	190	..
No. 4 ..	..	225	..	..	..	..	..	..	..
Armstrong's	..	..	..	..	..	130	840	220	110?

No. 1 ore-body cropped out at the surface, and extended to a depth of 180 ft. Its greatest length was 156 ft., and its maximum width 20 ft. The crush formation continued below the ore-body, and beneath the 200-ft. level a new ore-body, marked No. 1A on my plans, came in. The upper ore-body was never rich in silver even among the gossans, and the sulphides contained only 14 or 15 oz. per ton. The lower body, however, in the central part, averaged 52 oz. per ton at the 300-ft. level, with lesser values above and below.

No. 2N ore-body did not come within 30 ft. of the surface and consequently it suffered no oxidation. Its average silver content was less than 20 oz. per ton. The maximum horizontal sectional area was 240 square ft., and this was at the 90-ft. level, below which it gradually contracted, dying out altogether at the 200-ft. level.

No. 2S ore-body, having been naturally exposed, was oxidised to a depth of 96 ft. The sulphides carried up to 100 oz. silver per ton and generally assayed well, but they disappeared at 125 ft. depth. The formation was still well marked at the 150-ft. level, but beneath that it has not been recognised with certainty.



PLAN OF 150-FT. LEVEL, SILVER SPUR.

Armstrong's, a cupriferous ore-body, came in just below the 150-ft. level, on the western side of No. 3 ore-body, from which it gradually departed towards No. 1A, with which it junctioned at 275 ft. depth. It thus helped to constitute the great lens on the 300-ft. and 400-ft. levels, but below the latter it would appear to have pinched out. At the 300-ft. level, where best developed, it had a length of 108 ft. and a width of 12 ft.

The No. 3 ore-body crop is said to have been not more than 15 ft. long, and to have been poor in copper, but to have carried more than 40 oz. silver per ton. It rapidly increased in size below the surface, being 132 ft. long and 9 ft. wide at 150 ft. depth, but at the 200-ft. level it split up into several distinct lenses.

No. 4 ore-body carried 70 oz. silver per ton in the gossan and 35 oz. in the sulphide zone. It yielded a relatively small quantity of ore.

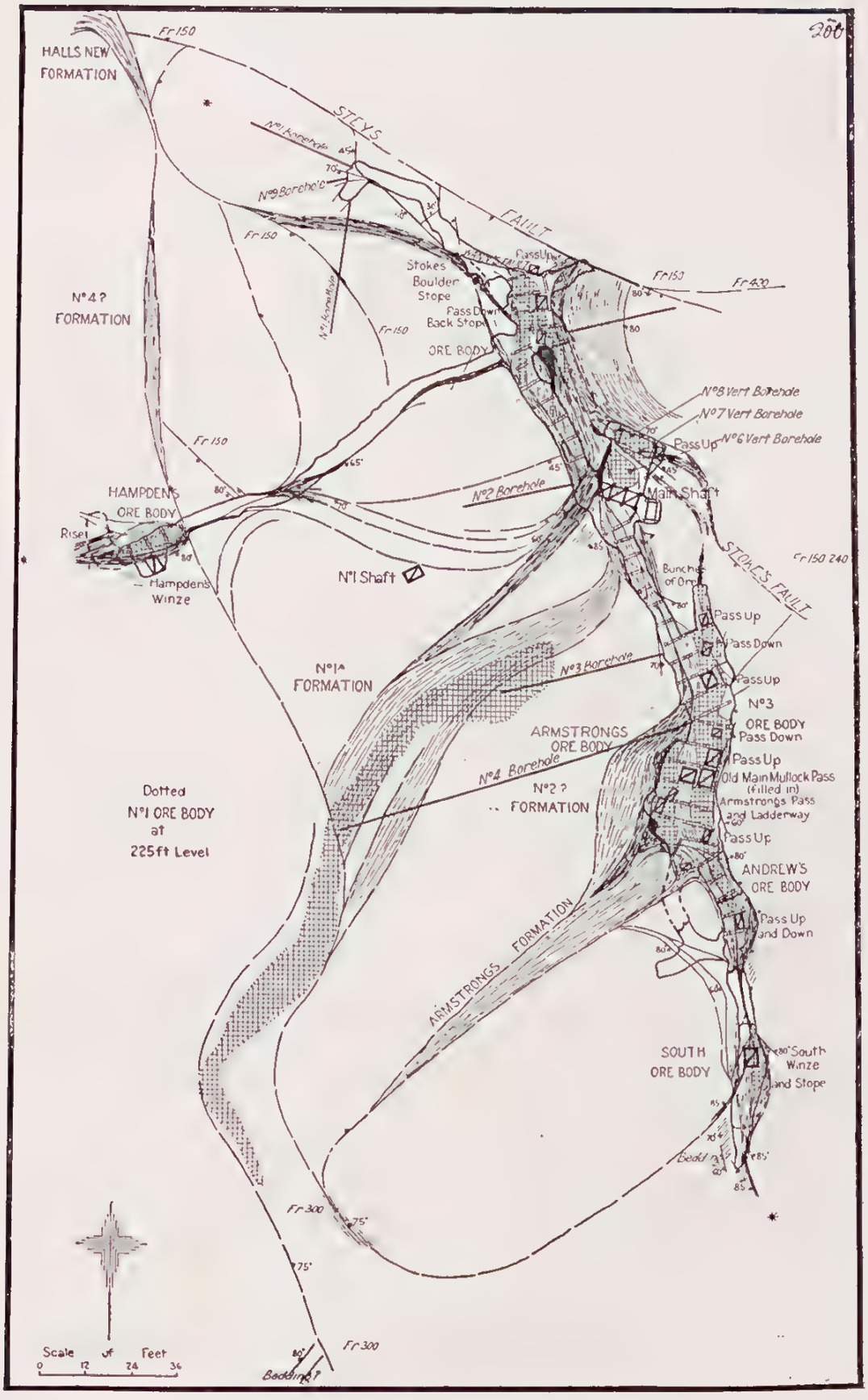
Hall's ore-body in the northern part of M.L. 68 cropped as silver-bearing plumbiferous gossan, but it has been sought in vain beneath the surface.

The office ore-body, according to Skertchly, was a small lens that persisted from the surface to 35 ft. depth, and assayed as much as 90 oz. silver per ton.

Besides those mentioned above, quite a number of small ore-bodies have been discovered during development, and where particulars have been recorded they have been plotted on the plans. At the 500-ft. level four ore-bodies have been located, but in each case only the upper edge or crest of the lens has been touched and the amount of ore exposed is not great. The management, however, is in hopes of the ore-bodies increasing greatly in size below the level; more especially as the silver content is believed to be above the average of the ore hitherto treated.

GENESIS.

The history of ore deposition at Silver Spur has been reconstructed by Mr. Skertchly in elucidating the geology of the Stanthorpe district. We may agree with him that the Permo-Carboniferous strata at Silver Spur were affected to the extent of fracturing under the axial strains induced during the intrusion of the Stanthorpe granite magmas, but it is not quite clear on what grounds the Silver Spur ore deposits were designated bedded veins. The dependence of ore deposition on igneous action was fully appreciated by Mr. Skertchly, yet he does not seem to have realised the necessity for greater proximity than

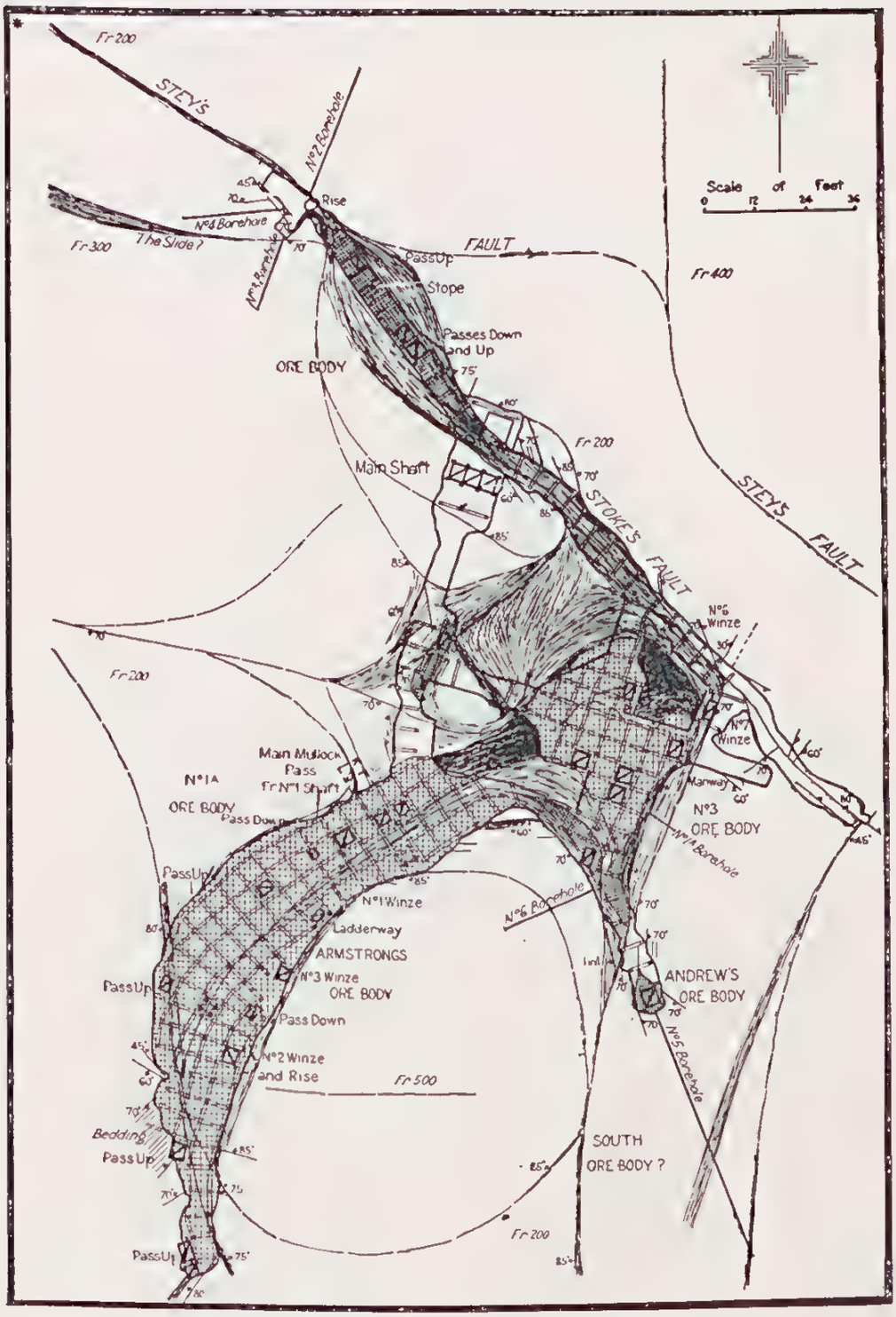


PLAN OF 200-FT. LEVEL, SILVER SPUR.

that of the Stanthorpe *massif*, and he overlooked the probability of an acidic intrusive, such as could supply the metallic minerals of the ore-bodies, occurring at a moderate depth directly beneath Silver Spur, though the diorite outcropping in the near vicinity of the mine might be regarded as due to magmatic segregation and advanced as collateral evidence.

The source of the ores and the mineralising solutions having been assigned to the igneous magma, and it being generally agreed that juvenile metalliferous solutions represent a final phase of igneous activity, it follows that the solutions passing into the crush formations in the sedimentaries were under pressure and at a high temperature, and that precipitation of the sulphides will have been dependent to some extent on the cooling of the uprising liquors. Among the first sulphides deposited, and that at no great distance from the igneous source, arsenopyrite bulks largely, but, passing outwards in the wake of the cooling solutions, other minerals predominate in turn: blende, galena, chalcopyrite. This certainly seems to have been the order at Silver Spur, where already at the bottom level the copper percentage is negligible, where lead is giving way to zinc, and where arsenic and bismuth have made an appearance. We should therefore not be surprised if it is found that we are now approaching the downward limit of sulphide deposition for the period of intrusion, below which pneumatolytic oxides will take the place of the minerals hitherto characteristic of the ore-bodies. The idea has already occurred to Mr. Hall that he may yet have to mine tin in place of silver-lead. Five hundred feet may seem an unusually small range, but it is possible that the upper limit of deposition was far above the present surface, and that great bodies of ore have been removed by denudation.

That the ore-bodies are replacements of masses of limestone is a fascinating hypothesis, especially in view of the known occurrence of such limestone lenses in the neighbourhood; but it does not seem likely that the replacement of the limestone could in every instance have been complete; and no sign of that rock has been met in exploiting the ore-bodies, though I found a few small nodules enclosed in the country rock adjacent to the ore-body at the 400-ft. level, these being similar to the coralline nodules that occur in the mudstones cropping in the vicinity of the mine. Alternatively it might be urged that the loci of the ore-shoots in the formations have been determined by inclusions of crushed calcareous mudstone particularly susceptible to metasomatic replacement; and the absence of such rock from the area as yet prospected at the 500-ft. level may be the reason for the relatively small development of ore-bodies in that part.



PLAN OF 300-FT. LEVEL, SILVER SPUR.

MINERAL PARAGENESIS.

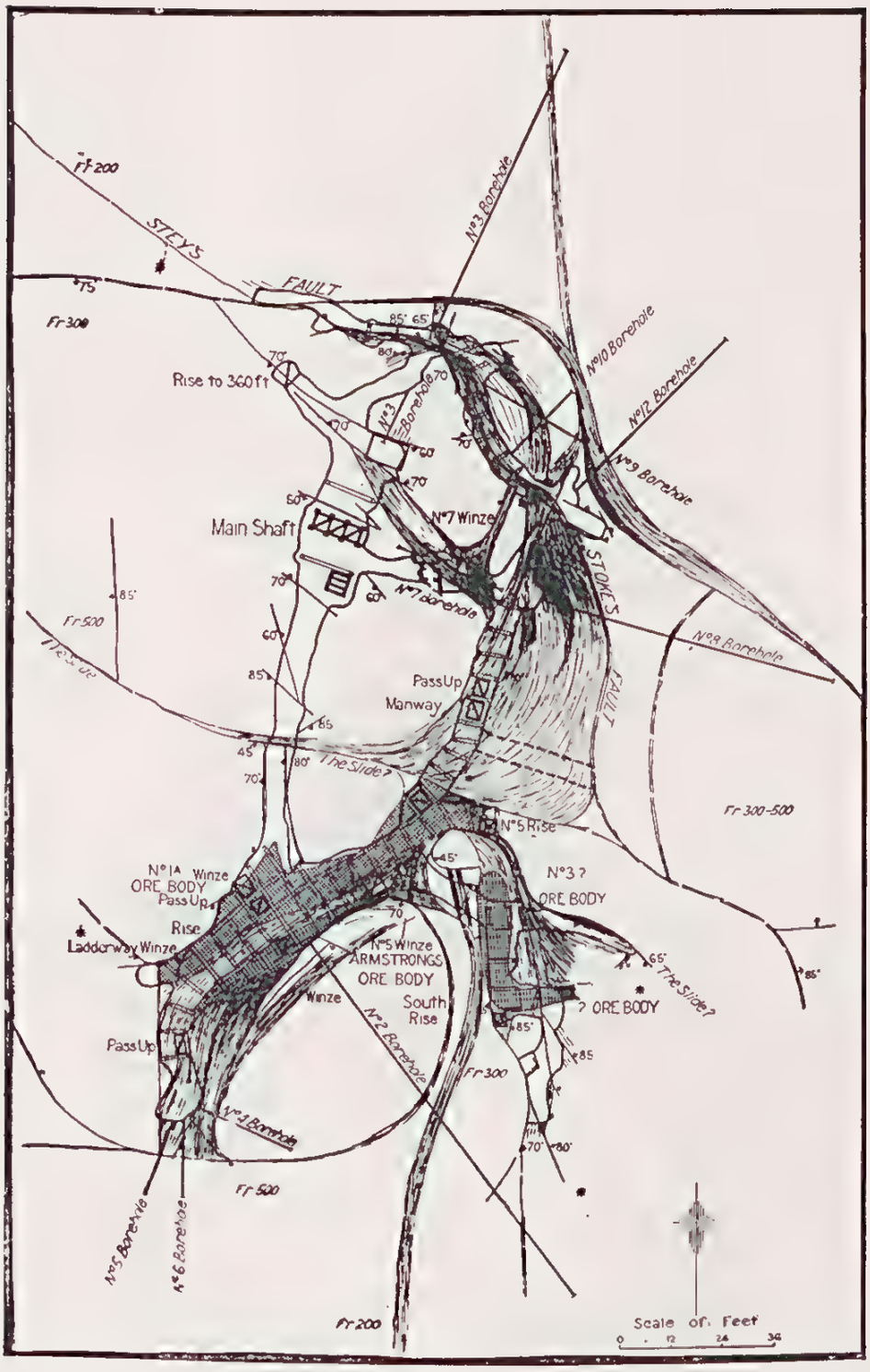
The upper portions of the ore-bodies exposed by denudation have suffered oxidation and appear as red and yellow gossans carrying carbonates (cerussite, calamine, malachite, azurite, &c.) and oxides. In some places these were found to be sharply marked off from the adjacent country rock, but often they were observed to gradually shade off, indicating replacement by the original sulphides.

Sulphates are the most common of secondary mineral deposits in the upper levels. They may be traced to the reaction of sulphuric acid (produced during the oxidation of pyrite) with various sulphides and gangue minerals. The insoluble calcium compound (gypsum) was observed as thin sheets in the formation at the 80-ft. level and lining joints in the pebbly slate on the 200-ft. level. The soluble efflorescent, stalactitic, and encrusting sulphates of the upper levels are transitional forms, the preservation of which depends on artificial conditions now prevailing. The species represented include the dark blue copper compound (chalcanthite), the greenish iron compound (melanterite), and probably the colourless zinc compound (goslarite), besides those of aluminium, magnesium, and the alkalis.

Semi-oxidised sulphides, slightly cellular and stained with malachite, are still to be seen at the 100-ft. level, and calamine occurs in quantity on partly oxidised zinc ore in the south stope on the 200-ft. level.

The sulphide ore closely simulates the structural peculiarities, especially the schistosity and lamination, of the crushed country of the formations, and generally it is difficult to distinguish off-hand between a mass of ore and the unattacked rock. The mixed sulphides comprise pyrite, blende, galena, chalcopyrite, &c. Much of the ore raised is dense and massive, especially the more plumbiferous material, the zinciferous portion on the other hand has a more granular structure, while the cupriferous parts frequently are laminated owing to the separation of chalcopyrite from mixed galena and blende. Pale brown blende and silver-white pyrite exhibit a tendency towards sporadic crystallisation, both in the mixed sulphide ore and in the adjacent country; but the chalcopyrite commonly is in streaming bands and arborescent forms. Arsenopyrite is nowhere distinguishable, but an analysis is quoted of arsenical ore from below the 400-ft. level. The only non-metallic gangue minerals observed were calcite* and quartz, the former to the extent of

* Strontium carbonate has been reported but its presence has not been confirmed.



PLAN OF 400-FT. LEVEL, SILVER SPUR.

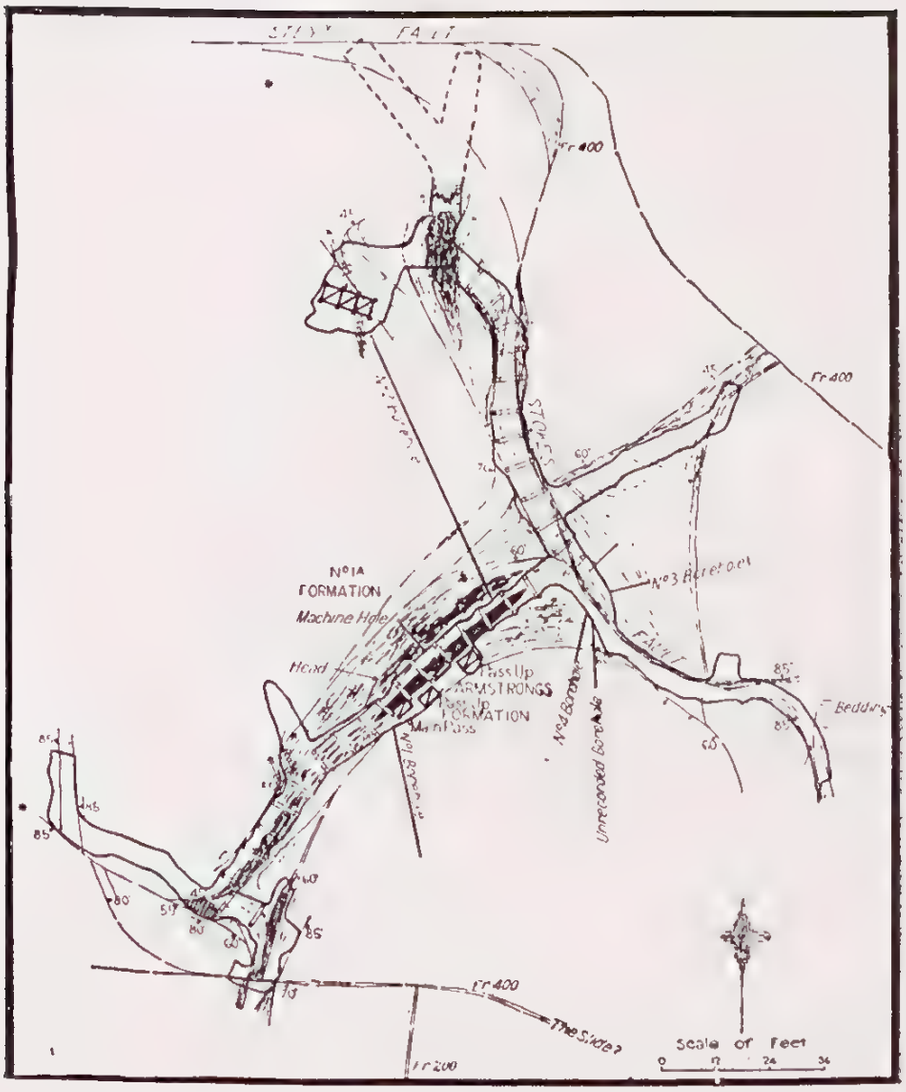
less than 1 per cent., but the latter rather more plentiful. Calcite is both disseminated and in vein form, while quartz-calcite and quartz are distinguishable in grain and vein form in various parts of the ore-bodies.

The ore of the New Make at the 150-ft. level is exceptional in having a matrix of fine-grained yellow pyrite, with 1/20-in. seams of blende that follow the outlines of replaced slate inclusions, the pyrite at the same time being veined and impregnated with calcite. Some of the zinc ore of the bottom level is unusual too in being simply slightly crushed slate with disseminated sulphides. Reddish blende occurs as 1/50-in. crystals in small impregnating masses up to ½ in. in diameter spaced an inch or two apart and to the extent of 20 per cent. of the rock. Crystalline brown blende occurs in 1/10-in. seams associated with (say 1 per cent.) chalcopyrite in stringers and a rare grain or film of galena (at most ½ per cent.) lying between the blende and the slate. Chalcopyrite (less than 1 per cent.) occurs as filigree indifferently in the slate, or in the blende and galena. Thus it is plain that the zinc was the first metal introduced and that the copper was the last. Owing to contained unstable sulphides, efflorescent sulphates appear on blocks of ore from the lower levels after a few weeks' exposure, and in some cases complete disintegration follows.

Mine waters, even if of meteoric origin, call for mention because of their action on the ores. The flows met in the various workings differ widely in their mineral content, and in the results produced by them, as shown below. An analysis of the mine water was made by Mr. Leon Meston in 1901, the sample presumably having been taken from the sump at the 300-ft. level:—

Silica	2·45 grains per gallon
Calcium carbonate	37·32 grains per gallon
Calcium sulphate	0·437 grains per gallon
Magnesium sulphate	23·77 grains per gallon
Magnesium carbonate	1·00 grains per gallon
Sodium sulphate	3·422 grains per gallon
Potassium sulphate	2·74 grains per gallon
Ferric sulphate	1·60 grains per gallon
Unestimated	2·261 grains per gallon
Total	75·000 grains per gallon

Sinters, thrown down from the mine waters, are met in the lower workings, both as hard lamellar encrustations and as soft muds and jellies. The slimy siliceo-calcareous sinter at the 400-ft. level is yellow to green, and as it dries it becomes enamelline and lamellar. Besides calcium carbonate



PLAN OF 500-FT. LEVEL, SILVER SPUR.

and silica it contains some zinc oxide. We may include here a crystalline granular pale brown ferruginous carbonate deposited from the water that issues from the borehole in the S. rise at the 300-ft. level, and the light canary yellow (zinciferous) muddy ochre thrown down on the floor of the drive from the southern end of No. 3 stope at the 150-ft. level.

Carbon dioxide is among the natural products of the mine, having been evolved until recently from No. 1 borehole (at the end of the north-western drive on the 200-ft. level) during a period of more than twelve years, in quantity sufficient to extinguish a candle placed at the mouth of the hole. Its source was probably in the calcite of some calcareous band acted upon by sulphuric acid resultant from the oxidation of a pyritic body.

MINERAL COMPOSITION.

The simplest way to arrive at the average mineral contents of all ores treated is to sum the metal totals recovered and those lost in smelting. In this instance loss of sulphur by volatilisation in the preliminary roast equalises the gains due to added flux, and the slag tonnage drawn from the furnaces amounts roughly to that of the ore raised. Hence we have:—

	Silver.	Gold.	Copper.	Lead.	Zinc.
Metals recovered	.. 22 oz. p. t.	1 dwt. p. t.	0·9%	1·1%	..
Metals lost in slag	.. 5 oz. p. t.	..	0·3%	4·5%	21%
Totalling	.. 27 oz. p. t.	1 dwt. p. t.	1·2%	5·6%	21%

This corresponds with chalcopyrite, 3½ per cent.; galena, 6½ per cent.; and zinc blende, 30 per cent.; but these figures are low, because no allowance has been made for loss by volatilisation of zinc and lead during the reduction of the sulphides.

Of course, the ore raised has varied to some extent from month to month and from year to year, though the recorded analyses do not happen to illustrate the point. Thus the average for several years ending December, 1909 (see table B, column 1), and Mr. Leon Meston's averages for the years 1900 (column 2) and 1901 (column 3) do not differ widely, except in the case of gold, from the analysis* (column 4) of a sample taken by me in 1909 of the ore stacked ready to be roasted. This last was of normal aspect, most of the galena, blende and pyrite being so finely granular and so thoroughly intermixed that their separa-

* By the Government Analyst.

tion by other than chemical means was impracticable. From the average analyses it would appear that ferriferous blende constituted about 45 per cent. of the ore won, with galena amounting to 16 per cent., pyrite 15 per cent., quartz 10 per cent., slate 10 per cent., chalcopyrite 3 per cent., and calcite 1 per cent. With regard to the slate it may be noticed that the sulphides at the 400-ft. level exhibit all stages in the replacement of country, from rock impregnated with ore to massive metallic minerals.

As differing somewhat from the above, an analysis of the sulphides from No. 1 ore-body at the 150-ft. level is quoted (in column 5), and from this we may calculate the mineral content as:—Pyrite, 35·7 per cent.; quartz, 26·3 per cent.; blende, 23·4 per cent.; galena, 7·4 per cent.; chalcopyrite, 6·3 per cent.; and pyrolusite, 1·2 per cent. The zinc ore above the 300-ft. level as mined in 1914 assayed Ag., 23 oz. pt.; Pb., 17 per cent.; and Zn., 38 per cent.; and therefore contained galena to the extent of 19½ per cent., with 57 per cent. blende. The arsenical ore met in the lower levels of the mine has been shown to carry abnormal silver and gold values. An instance of this was the ore raised from No. 5 winze below the 400-ft. level, this averaging (as calculated from the 6th column):—Arsenopyrite, 23·0 per cent.; pyrite, 15·4 per cent.; blende, 14·5 per cent.; and galena, 6·1 per cent. The more siliceous low-grade ore from the same place contained also a trace of bismuth, this being also a quite exceptional phenomenon and suggestive of approach to the intrusive, the source of all the metals.

Table B.

—	1.	2.	3.	4.	5.	6.
Silver, oz. per ton ..	26 to 35	26⅓	22	24	16	74·9
Gold, dwt. per ton ..	1	..	..	14*	1	3
Copper, %	0·67 to 1·4	1·08	1·36	1·1	2·20	..
Lead, %	12·5 to 14·0	13·08	12·50	13·7	6·46	5·5
Zinc, %	23·9 to 27·2	25·30	27·20	27·4	11·40	9·7
Cadmium, %	..	..	..	nil	..	..
Iron, %	10·6 to 16·2	16·14	10·60	9·8	24·57	..
Manganese dioxide, %	..	..	..	..	1·19	..
Sulphur, % ..	27·8 to 29·0	28·5	28·70	..	27·83	18·4
Arsenic, %	..	..	trace	..	..	10·6
Silica, %	13·5 to 17·0	14·2	13·62	17·0	26·35	..
Alumina, % ..	..	..	4·60	4·0	..	..
Calcium carbonate, %	..	..	0·70	..	..	..

* This high gold content has not been explained, and needs confirmation.

Gold values (averaging as above 1 dwt. per ton) are highest in the most siliceous ore, as proved by Mr. Hall's assays of ore from Williams's stope at the 360-ft. level.

—	Pyritic.	Quartzose.
Silver	27 oz. per ton ..	9 oz. per ton
Gold	3¼ dwt. per ton	6¼ dwt. per ton

Highly auriferous ore is met occasionally. Thus the first ore broken down at the new make on the 150-ft. level yielded:—

Gold, 4 oz. per ton; and silver, 73 oz. per ton.

Silver by recovery has amounted to 22 oz. per ton of ore, with 5 oz. lost in the slags. The richer the ore is in galena the richer it is, as a rule, in silver, but on the 500-ft. level the highest values (30 oz. per ton) were in the more pyritic sections, the richly cupriferous ore at the same time assaying less than 20 oz. The zinc ore is nowhere highly argentiferous, and some of it ran as low as 8 oz. per ton. The distribution of silver values in the 360-ft. stopes has been ascertained by Mr. Hall to be as under:—

—	Cupriferous Ore.	Pyrite.	Blende.	Laminated Cupriferous Ore.
Silver, per ton	42 oz.	36 oz.	17 oz.	12 oz.

From figures published by Mr. Skertchly it would seem that the gossans first treated ran very much higher in silver than the sulphides, the respective contents of the two classes of ore raised during 1894 and 1895 being 49 oz. and 25 oz. Native silver was found at several places in the upper workings, particularly in the oxidised ore; but among the sulphides also it has been observed in the quartzose ore of the new make at the 150-ft. level and in the adjacent indurated calcite-veined slates; and besides appreciable quantities were got in association with the dark crush material adjacent in No. 1A ore-body at the 300-ft. level. Exceptionally high silver values were reported from the hanging-wall side of the big ore-body at the 300-ft. level, some assays returning as high as 100 oz. per ton, owing to the presence of much ruby silver and fahlore (?) with chalcopyrite. Mr. Hall, in his report for 1903, stated that "Ruby silver (proustite) is now found to be a constituent of the ore-bodies at the 100-ft., 200-ft., and 300-ft. levels, and exists in largest quantities at the lowest level, where it is taken as an indication that high-grade

ore may be expected to continue in depth in this mine.'' As events proved, the high-grade ore did not continue, though traces are said to have been detected in the northern ore-body at the 500-ft. level, and the proustite must be regarded as of secondary origin, due to downward leaching of silver salts.

Lead, in galena, is never conspicuous, but there are some thin anastamosing filaments, visible to the naked eye. The average recovery of lead is 1·1 per cent., but allowing for 4½ per cent. lost in the slags, the average galena equivalent would be about 6½ per cent. The ore analyses indicate 16 per cent.

Copper is contained in the ore as chalcopyrite, this mineral's calculated proportion being 3½ per cent. (allowing for 0·9 per cent. copper recovered and 0·3 per cent. lost in the slags). The possibility of a small amount of tetrahedrite occurring in some of the ore has not been overlooked, but it has not actually been detected and is not expected generally on account of the absence of arsenic from most analyses. The failure of the metal in the deeper workings was the chief cause of the cessation of smelting here, a handicap that has now been removed by the addition of purchased blister copper to the furnace charge. Copper sulphate is commonly present in the mine water and is plentiful as an incrustation in some of the old workings, more particularly in the No. 1 stopes on the 100-ft. level. Slight stains of carbonate also are noticeable in the footwall country of Armstrong's lode as far down as the 250-ft. level.

Zinc is combined in blende, mostly as the dark ferriferous variety and in dense massive form. The yellow non-ferriferous sulphide occurs associated with the ferriferous in the No. 3 ore-body at the 300-ft. level, and crystalline reddish blende impregnates crushed slate at the 500-ft. level. A small quantity of carbonate of zinc* was found below the 300-ft. level, and the same mineral forms a coating on the footwall of No. 1A ore-body at the 240-ft. level, while that from the 200-ft. level has been shown by Mr. Leon Meston to contain: Zinc carbonate, 86·05 per cent., and iron carbonate, 10·02 per cent.

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* Mr. Hall writes that ''Zinc carbonate was very plentiful, amounting in the aggregate to probably several hundred tons, if it had been sorted out. It was often 2 in. thick, and I have regretted that we did not instal a sorting plant and sort it out; I believe it would have paid us well. At one place in the mine there were cavities with angular pieces of sulphide ore coated with that carbonate about one-third of an inch thick, which I regarded as proof of quite recent earth movements here.''

Iron minerals of the ore comprise ferriferous blende, chalcopyrite, pyrite, and arsenopyrite, and analyses show the metal to be present in quantities varying between 10 per cent. and 25 per cent. Most of the ore has contained sufficient for smelting, only small additions of iron ore having been required as flux. Striated cubes of pyrite, mostly less than $\frac{1}{3}$ in. in diameter, are abundant in parts of the formation at the 500-ft. level.

Manganese, as pyrolusite, has been recorded by Mr. Stokes as occurring to the extent of 1 per cent. in the No. 1 ore-body at the 150-ft. level.

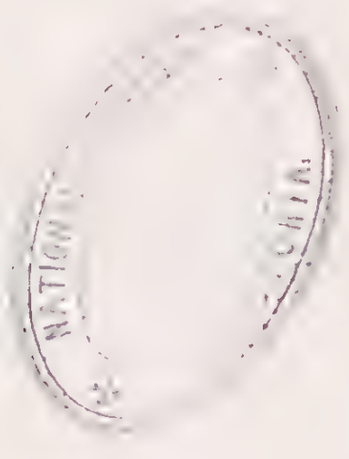
Bismuth has been recorded in only one analysis, that of the purchaser of the siliceous lower-grade portion of the arsenical ore raised from No. 5 winze below the 400-ft. level. The amount given is 0·004 per cent.

Sulphur is present in the primary sulphides of the metals, but it occurs also in the secondary sulphates, and Mr. Hall tells me that it existed quite abundantly in the elemental form on every crevice of the sulphide ore from 100 ft. to below the 150-ft. level.

Silica, as quartz in the form of segregations in the slates, is probably older than the ore-bodies, and it is nowhere visibly metalliferous. The vein quartz of the ore-bodies on the other hand is associated with richly argentiferous and sometimes auriferous ore.

Lime, combined in calcite, though indicated by analysis, is not a conspicuous constituent of the ore. It does, however, occur as small lenses in most of the formations, being particularly noticeable on the bottom level, where it is coarsely crystalline.

28th February, 1918.



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